FILM COOLING HOLE FOR TURBINE AIRFOIL

FEDERAL RESEARCH STATEMENT

None.

CROSS-REFERENCE TO RELATED APPLICATIONS

None.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to a gas turbine engine, and more specifically to an air cooled airfoil in the engine.

Description of the Related Art including information disclosed under 37 CFR 1.97 and 1.98

Airfoils used in a gas turbine engine, such as rotor blades and stator vanes (guide nozzles), require film cooling of the external surface where the hottest gas flow temperatures are found. The airfoil leading edge region is exposed to the highest gas flow temperature and therefore film cooling holes are used here. Film cooling holes discharge pressurized cooling air onto the airfoil surface as a layer that forms a blanket to protect the metal surface from the hot gas flow. The prior art is full of complex film hole shapes that are designed to maximize the film coverage on the airfoil surface while minimizing loses.

Standard film holes pass straight through the airfoil wall at a constant diameter and exit at an angle to the airfoil surface. This is shown in FIGS. **1** through **7**. Some of the cooling are is ejected directly into the mainstream flow and causes turbulence, coolant dilution and a loss of downstream film effectiveness. Also, the hole breakout in the streamwise elliptical shape will induce stress problems in a blade application.

An improvement of the straight film hole is the diffusion hole shown in FIGS. 8 through 10 which is disclosed in U.S. Pat. No. 4,653,983 issued to Vehr on Mar. 31, 1987 and entitled CROSS-FLOW FILM COOLING PASSAGES, which discloses a film hole with 10×10×10 streamwise three dimension diffusion hole. This type of film cooling hole includes a constant cross section flow area at the entrance region for the cooling flow metering purpose. Downstream from the constant diameter section, is a diffusion section with diffusion in three sides that include the two side walls and the downstream wall in which each of these three walls have a diffusion angle of 10 degrees from the hole axis. However, in the Vehr hole there is no diffusion in the upstream side wall (the top wall in FIG. **9**) in the streamwise direction. During the engine operation, hot gas frequently becomes entrained into the upper corner and causes shear mixing with the cooling air flowing through the hole. As a result of this, a reduction of the film cooling effectiveness for the film cooling hole occurs. Also, internal flow separation occurs within the diffusion hole at the junction between the constant cross section area and the diffusion region as seen by the arrow in FIG. **11**.

BRIEF SUMMARY OF THE INVENTION

It is an object of the present invention to provide for a film cooling hole that will produce less turbulence than the citer prior art film holes.

It is another object of the present invention to provide for a film cooling hole that will produce less dilution of the film cooling air than the film holes of the cited prior art.

It is another object of the present invention to provide for a film cooling hole that will have a higher downstream film effectiveness than the film holes of the cited prior art.

It is another object of the present invention to provide for a film cooling hole that will produce less internal flow separation within the diffusion hole than the film hales of the cited prior art.

The film cooling hole of the present invention includes a metering section and a diffusion section that includes flow guides to form separate diffusion passages in order to minimize shear mixing between the cooling layers versus the hot gas stream. In one embodiment, three flow guides form four separate diffusion passages each having an expansion in both sideways and downstream walls of the passage. The two inner passages have the same flow area and the two outer passages have the same flow area at the exits. The middle flow guide is shorter than the two outer flow guides so that three inlets for the four passages are formed where all three inlets have the same flow area.

In a second embodiment used in a compound angled bell-mouth shaped film hole, four flow guides form five diffusion passages with an inner passage, two middle passages and two outer passages. Two inner flow guides are shorter than the two outer flow guides and form three inlets to the five passages. Each passage expands in both side wall directions and the downstream side wall direction. No expansion is formed in the upstream side wall.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** shows a top view of a prior art straight film cooling hole.

FIG. **2** shows a top view of a prior art radial film cooling hole.

FIG. **3** shows a top view of a prior art compound angled film cooling hole.

FIG. **4** shows a cross section view of the straight film hole of FIG. **1**.

FIG. **5** shows a cross section view of the radial film hole of FIG. **2**.

FIG. **6** shows a cross section view of the compound angled film hole of FIG. **3**.

FIG. **7** shows a cross section view of an airfoil with one of the film cooling hole on the suction side wall.

FIG. **8** shows a top view of a prior art film cooling hole with the 10 by 10 by 10 expansions in three side walls.

FIG. **9** shows a cross section side view of the prior art film cooling hole of FIG. **8**.

FIG. **10** shows a cross section view of an airfoil with one of the film cooling hole of FIG. **8** on the suction side wall.

FIG. **11** shows a cross section side view of the prior art film cooling hole of FIG. **8** with the flow separation and hot gas ingestion.

FIG. **12** shows a first-embodiment of the film cooling hole of the present invention from a top view.

FIG. **13** shows a first embodiment the film cooling hole of the present invention from a cross section side view.

FIG. **14** shows a second embodiment of the film cooling hole of the present invention from a top view.

FIG. **15** shows a second embodiment the film cooling hole of the present invention from a cross section side view.

DETAILED DESCRIPTION OF THE INVENTION

The film cooling holes of the present invention are shown in FIGS. **12** through **15** where the first embodiment is shown